



August 2008 Unit 2 Transformer Failure
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Event

- At 2356 on 8/16/08, a failure related to the Unit 2 Main Transformer (MT) "C" phase resulted in a Unit trip and a Reactor trip.





Post Event Investigation

- A post event investigation was performed to evaluate the plant response to the event and determine the preliminary cause of the plant trip. The investigation concluded:
 - A reactor trip was generated as a result of the unit trip (generator trip)
 - The reactor coolant system including the replacement steam generators responded as expected.
 - The plant electrical protection system responded as expected.
 - The transformer deluge system (fire mitigation system) responded as expected
 - There was a need for an enhancement to plant operating procedures to improve post trip auxiliary feedwater operation. A procedure change was processed immediately.
 - Personnel safety enhancements (area restricted and protection added to Admin Building windows) were prudent for working around energized oil filled transformers. These enhancements are being or have been implemented prior to resumption of regular work activities in the affected areas.



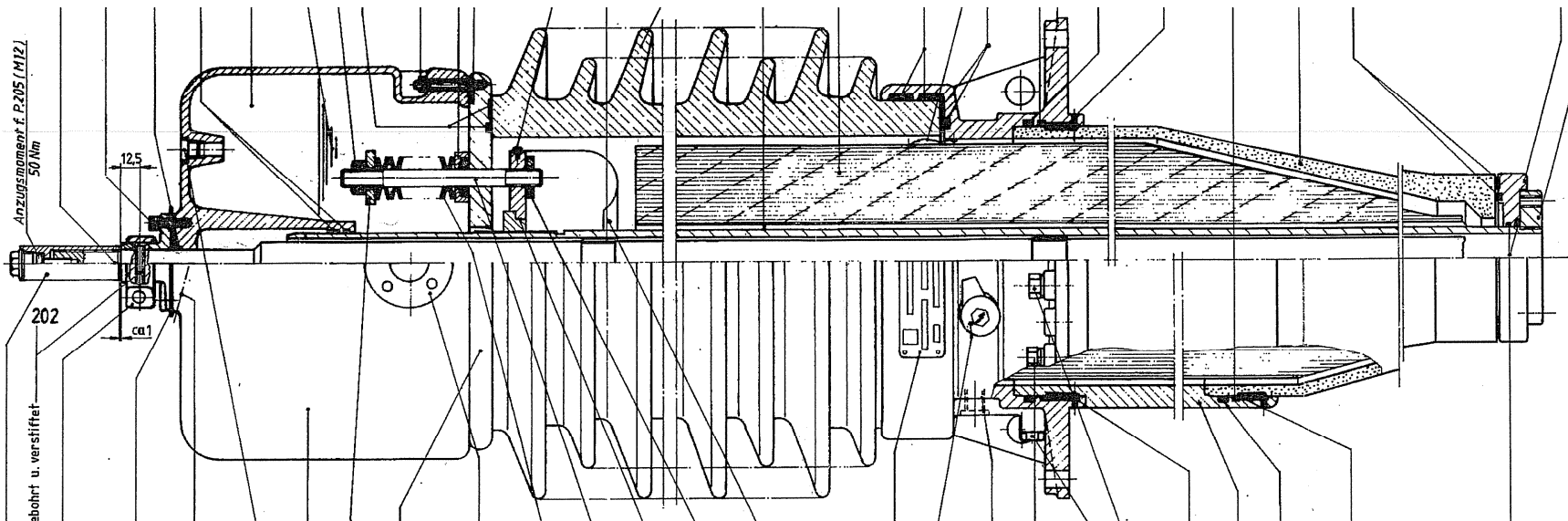
Preliminary Cause

- The preliminary cause investigation determined that the event was the result a phase to ground fault at the “C” phase main bank transformer high voltage bushing.
- A root cause analysis is underway to determine the cause of the bushing failure.
- The root cause analysis will identify the cause of the bushing failure as well as any additional corrective actions to prevent recurrence. These corrective actions will also address similar equipment that might be susceptible to the same failure mechanism.

DCPP Unit 2 Oil Filled Bushing

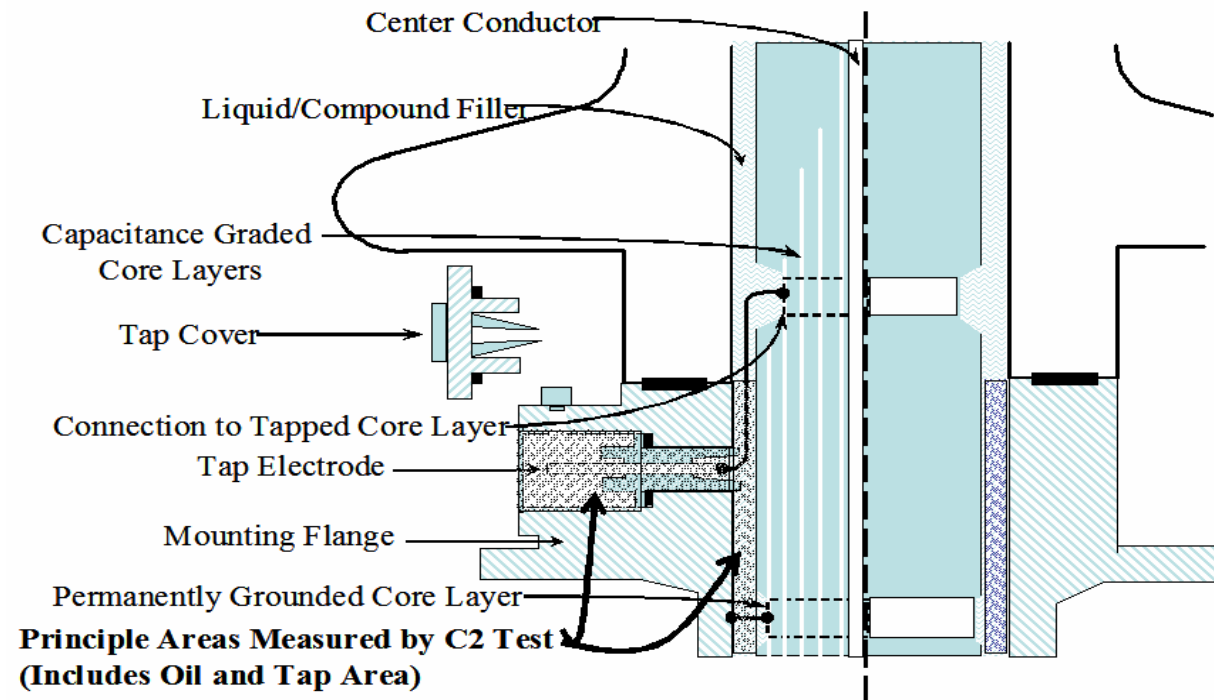
•MAJOR COMPONENTS:

- Termination Head/Oil Reservoir, Copper Conductor, Aluminum Sheath, Condenser (bushing oil, paper and aluminum foil), Porcelain, Mounting Flange, Oil Part Envelope, Test Tap, and Transformer Oil, Lower Termination Bus Bar



Typical Oil Filled Bushing

Typical Bushing Potential Tap Construction





Immediate Corrective Actions

- The following corrective actions were taken to address the preliminary cause and prevent recurrence of the event:
 - Replace Unit 2 "C" Phase transformer
 - Test Unit 2 "A" and "B" transformers (including bushings), all lightning arresters, and all Capacitor Coupled Voltage Transformers (CCVTs).
 - Verify oil levels in all 3 main bank high voltage bushings.
 - Install on-line bushing monitoring system on Unit 2 Main Bank HV Bushings.
 - Clean and re-grease all 500 kV transformers, CCVTs, and lightning arrester porcelain insulators.
 - Add high voltage bushing oil level inspection to daily operator rounds.
 - Sample and test oil from "A" and "B" bushings.
- These corrective actions provided validation that the remaining high voltage bushings were in good condition and provides a means to determine if this condition changes.



As Found Transformer Conditions

- The as-found transformer conditions were:
 - Exterior support components (control panel, wiring, hydrant monitor) were found burned from the fire.
 - Internals (windings, core and tap changer) were in good condition and tested good electrically once the bushing and high voltage termination leads were removed.
 - Oil samples showed signs for dissolved gases. The dissolved gases were the result of the bushing failure. Review of quarterly oil samples maintenance records did not show elevated dissolved gases in the transformer oil prior to the event.



As Found Bushing Conditions

- The as-found high voltage conditions were:
 - All upper bushing porcelain has failed
 - A section of the insulation system was failed at the mounting flange
 - A section of the insulating system was failed about 200cm from the top and the insulation system was pushed away from this point in both directions. In addition, there were melted aluminum at this same location on the aluminum sheath
 - Signs of partial discharge in the insulating system.
 - The oil part envelop (low oil barrier) was failed
 - There were no signs of overheating or long term degradation
 - The copper conductor was not damaged



Root Cause Analysis

- The formal root cause analysis began (on September 8, 2008) after successful testing and installation the spare main bank transformer in the Unit 2 “C” phase transformer location.
- The root cause team is comprised of representatives from Engineering, Operations, Maintenance, Learning Services and an independent consultant.
- The root cause analysis team is currently evaluating the onsite bushing failure analysis (included manufacturer, PG&E experts, and independent consultant), failed transformer historical test data, industry operating experience, industry best practices for transformer maintenance, forensic evidence, plant responses, 500 kV system conditions and environmental conditions.



Root Cause Analysis

- The root cause analysis has focused the potential causes to:
 - Degraded ground on the HV Bushing Test Tap
 - Low Bushing oil level
 - Paper degradation / thermal aging
 - Bushing oil quality.
- The bushing monitoring system installed during the 2T15 forced outage is effective at early identification for any of these potential causes or changes in the bushing insulating system.
- Other extent of condition corrective actions (i.e. enhanced performance monitoring, addition bushing monitoring systems, maintenance frequency changes) are currently being developed.



Questions?